ISSN: 2957-9082
https://doi.org/10.56946/jspae.v1i2.71 *Journal of Soil, Plant and Environment*

ORIGINAL RESEARCH

Evaluation of integrated nutrient management on soil health, maize productivity and grain quality

Karanbir Kaur, Neeraj Rani*

Punjab Agricultural University, Ludhiana, Punjab, India-141004
Corresponding Author: neerajsoil@pau.edu

Received: 05 Nov 2022
Revised: 17 Dec 2022
Accepted: 22 Dec 2022

ABSTRACT: Managing various organic residues produced from agricultural waste is today's prominent need. The present experiment was conducted to evaluate the effect of integrated, chemical, and organic fertilizers on maize productivity. Initially, overoptimistic was prepared using different organic residues *viz.*, paddy straw, neem leaves and dhaincha leaves, each in combination with cow dung in 1:1 ratio. Further, prepared overoptimistic along with integrated nutrient and chemical fertilizer treatments, were tested on maize productivity. The experiment was carried out in Randomized Block Design. The average two-year data revealed the increased yield and yield attributes of maize with integrated nutrient management followed by the recommended dose of fertilizers and different overoptimistic treatments. The least maize productivity was noted with control treatment. The different overoptimistic treatments comparatively improved the organic carbon (0.43 to 0.45%) and micronutrient status of the soil in second year of application (Fe- 10.85 to 13.32 mg kg^{-1}, Zn- 2.95 to 4.18 mg kg^{-1}, Cu- 0.55 to 0.73 mg kg^{-1}, Mn- 10.37 to 15.24 mg kg^{-1}). The result of overoptimistic application can be recorded higher in terms of improvement in yield and soil properties in the later years, as the initial organic carbon and nutrient content of the experimental soil was recorded to be low, and, it takes almost three to four years for positive response of soil to the applied organic amendments. Therefore, long-term experiments are required to evaluate the effects of overoptimistic on soil chemical properties and maize productivity. The investigation revealed that integrated nutrient treatment proved better in terms of improving the yield and nutrient status of the soil.

KEYWORDS: Cob, earthworms, grains, soil; mineralization

1. Introduction

Maize is the most significant crops in India and all over the world (Sadiq et al., 2017). The history of maize regarding its cultivation was in Europe, Oceania, Asia, and Africa, isn't much ancient, despite the fact that the climatic conditions in these regions are suited for its production (Majnoon 2006; Bolanle et al., 2022). Recently, the cultivation and consumption of maize crop in different regions have risen substantially around the world, possibly due to its relevance in the production of various products. Maize requires several types of sustenance throughout its growth that can be supplied from chemical fertilizers. Among different elements nitrogen is among the most significant components utilized in maize production, and a lack of it might limit the

nutritional elements of this crop (Wu et al., 2021; Khalid and Islam 2001).

Global hunger levels remain disturbingly high. According to the findings of the GRFC 2022, they eclipsed all prior records reported by the Global Report on Food Crises (GRFC) in 2021, with nearly 193 million people severely food deprived and in dire need of immediate assistance throughout 53 countries/territories. This marks an almost 40 million people increase over the previous high set in 2020 (GRFC 2021) (2022 Global Report on Food Crises/fao.org). Traditional farming no longer overcome the food demand; while chemical fertilizers have led to high production, they have also aggravated environmental damage. Effective management and application of balanced inputs is required for a fruitful establishment of crops (Dai and Dong 2014, Amin et al. 2017), particularly nitrogen, phosphorus, and potassium being critical elements for both cereal legume inter-crops (Divitoand Sadras 2014; Ali et al., 2019). In modern agriculture, the overuse of chemical fertilizers for high agricultural output has become popular (Ali et al., 2020). As a result, chemical fertilizers by itself are unable to sustain long-term fertility; thus, these fertilizers can be combined with overoptimistic, which is generated by the combination of various waste organic sources. This is known as co-composting, and it has been established profitable by increased wheat crop yields using animal manure, sludge leftovers, sawdust, and wood chips. This application of chemical fertilizers along with organic manure is growing popular among farmers due to growing awareness and enhanced productivity while maintaining soil fertility. Another study found that using organic fertilizer instead of chemical fertilizer raised soil pH and nutrient content while increasing microbial biomass (Iqbal et al., 2020). As a result, researchers recommended the use of organic compounds for increased crop yield and nutrient-rich soil preservation over a prolonged period of fertility conditions. Along with increased production, these fertilizers and pesticides have a deleterious influence on human health and reduce soil nutrient productivity and efficiency. Due to the environmental degradation caused by excessive nitrogen fertilizer use, an alternate technique based on biological origin, appropriate, and less expensively manufactured for nitrogen management is required. The use of overoptimistic to substitute nitrogen fertilizer in the soil can help to reduce environmental pollution created by removing nitrate from the soil (Raza et al., 2022). Additionally, the use of overoptimistic along with manure resulted in a better and significant enhancement in the functioning of seeds of maize and oats (Nanjappa et al. 2001; Jayanthi et al. 2002). According to research findings, using overoptimistic not only improves plant growth but also improves crop performance (Raza et al., 2022). The application of overoptimistic in sustainable agriculture increased the beneficial soil microorganisms, including mycorrhizal fungi and phosphate-dissolving bacteria and fungi.

Keeping these considerations in view the present study entitled "Evaluation of different organic waste materials for preparing overoptimistic and their effect on maize productivity" was conducted with the objective to study the effect of different rates

of prepared overoptimistic on growth and yield of maize.

2. Material and methods

2.1 Experimental deign and location

The present field experiment was conducted during Kharif 2019-20 and 2020-21 at the Integrated Farming System Farm, Punjab Agricultural University, Ludhiana situated at 30°54'N latitude and 75°48'E longitude at an altitude of 247 m above sea level. Initially, overoptimistic was prepared using different organic residues such as paddy straw (*Oryza sativa*), neem leaves (*Azadirachta indica*), dhaincha leaves (*Sesbania bispinosa*) and were combined with cow dung in 1:1 proportion i.e. {Paddy Straw + Cow dung (1:1)}, {Neem leaves + Cow dung (1:1)}, {Dhaincha leaves + Cow dung (1:1)} and {Cow Dung (100%)} for preparation of overoptimistic. The prepared overoptimistic (sieved through 4mm sieve) from different residues were tested on maize crop. The maize variety PMH 1 was sown in last week of July in 2019-20 and first week of July in 2020-21 (Kharif season) with recommended package of practices of PAU.The experiment includes seven treatments with three replications and was carried out in Randomized block design. The different treatments were control, RDF (Recommended dose of fertilizers), RDF+FYM (Recommended dose of fertilizers + Farmyard manure), Paddy straw + cow dung (1:1) + 1kg earthworms, Neem leaves + cow dung (1:1) + 1kg earthworms, Dhaincha leaves + cow dung (1:1) + 1kg earthworms. The harvesting was done in the first week of November 2020 during first year and last week of October 2021 in the second year.

2.2 Soil Analysis

The experimental soil was of loamy sand texture. Before the start and end of experiment, soil samples were collected and analyzed for various chemical properties. The initial sample of soil used for cultivation of maize crop was with neutral pH (7.2), normal electrical conductivity (EC) (0.37 dS m^{-1}) and low organic carbon (OC) content (0.38 %). The soil was recorded with low available nitrogen (AN) (109.8 kg ha^{-1}), medium available phosphorus (AP) (16 kg ha^{-1}) and medium available potassium (AK) (168.0 kg ha^{-1}). The soil pH and EC was analyzed with 1:2 soil:water suspension (Jackson 1967). The organic carbon (OC) percent of soil was analyzed with Walkley and Black's rapid titration method (Walkley and Black 1934). The macronutrient content *viz,* nitrogen, phosphorus and potassium (N, P & K) content of soil was analyzed with modified alkaline potassium permanganate method (Subbiah and Asija 1965), 0.5N Sodium bicarbonate extractable P by Olsen's method (Olsen et al. 1954) and ammonium acetate extractable K method (Jackson 1967) respectively. Whereas, the soil micro-nutrient content was analyzed by atomic absorption spectrophotometer method (Lindsey and Norvell 1978).

2.3 Grain and straw analysis

The straw and grain samples were also collected after harvesting for analysis of N, P, K and micro-nutrient content. The total nitrogen (TN) content was analyzed by Kjeldahl digestion procedure as given by Bremner and Hauck (1982), total phosphorus (TP) content measured using the Vanado-Molybdo-Phosphoric yellow colour method (Jackson 1967) and total potassium (TK)

content was analyzedby Flame Photometer (Jackson 1967). The micronutrient content (Fe, Cu, Zn, Mn) of maize grains and straw was analyzed by atomic absorption spectrophotometer (Lindsay and Norvell 1978).

2.4 Growth and yield attributes

Plant height, ear length, Number of grains per row, tassel size, grain size, 1000 grains weight, maturity days and yield were noted. The data was recorded before harvesting of crop.

2.4.1 Plant Height

Ten plants from each plot was randomly picked and plant height was measured. The mean values were recorded from each plot in cm. The measurement of plant height was done before harvesting from ground level to the whorl base.

2.4.2 Number of leaves per plant

The leaves number per plant were counted ignoring the dry leaves at the base of plant from ten randomly selected plants and the mean values was recorded.

2.4.3 Ear Length

Ten ears per plot was randomly selected and ear length was measured. The ear length was measured from base to tip of the ear and the mean values were noted from each plot in cm.

2.4.4 Number of grains per row

The grains number per row was recorded from five randomly selected cobs per plot were counted and mean values were recorded.

2.4.5 Tassel size

Ten tassels per plot was randomly selected and tassel size was measured from base to the tip. The mean values were recorded from each plot.

2.4.6 1000 grain weight

Thousand grains were taken and then counted manually from each plot and weighed in grams.

2.4.7 Cob length (cm)

Five cobs per plot were randomly selected and cob length was measured. The mean values were recorded from each plot in cm.

2.4.8 Number of rows per cob

The Number of grain rows from five representative cobs selected randomly from each plot were counted and mean values recorded.

2.4.9 Number of grains per cob

No. of grains per cob were worked out by multiplying no. of rows by no. of grains per row from five cobs randomly selected from each plot.

2.4.10 Grain size

The thickness and length of the grains was recorded in mm with vernier caliper. The size of randomly selected five grains was measured and the average was recorded as grain size from each plot.

2.4.11 Grain yield

All the cobs from net plot were left for sun drying for about fifteen days and threshing was carried out. The grain yield was adjusted to 15 per cent moisture level and expressed as q ha^{-1}.

2.4.12 Stover yield

After picking the cobs, the leftover plant material, including the husk, was left for sun drying, weighed, and presented as stover yield (q ha^{-1}).

2.5 Statistical analysis

Statistical analysis of the different parameters were analyzed with the help of analysis of variance (ANOVA) technique (Gomez and Gomez 1984) for randomized block design using CPCS1 software developed by the Department of Mathematics and Statistics, PAU, Ludhiana (Cheema and Singh 1991). The data were compared with a significance level test at $p < 0.05$.

3. Result and Discussions

3.1 Soil properties

3.1.1 pH, EC and OC

Soil pH in the most important factor, which affect nutrient availability in soil (Brandy and Weil 1996; Devkota et al., 2022; Ali et al., 2022). In the present study, the initial soil was 7.2. In this two-year experiment, no significant differences were noted among different treatments and the pH lies in the neutral range (Table 1). EC of soil is the measurement of amount of salts in the soil (salinity). It is a good predictor of loss and availability of nutrients, soil texture, and accessible water capacity. Compared to the initial soil sample, the slight increase was recorded as presented in table 1. On an average, the higher soil EC was recorded with Dhaincha leaves overoptimistic treatment which lies at par to other overoptimistic treatments but showed slight increase in comparison to integrated nutrient treatment, RDF and control treatments. With the increase in soil organic carbon levels, it leads to improved soil health and hence crop yield. The average of two years data represented a comparatively slight increase in the soil organic carbon content with different overoptimistic treatments (Table 1). The soil supplied with neem leaves overoptimistic and dhaincha leaves overoptimistic showed significant increase in comparison to the control treatment. This might be due to the fact that overoptimistic upon decomposition improves the organic carbon status of soil. Chimdessa and Sori (2020) reported that soil organic carbon status was higher with the overoptimistic (1.5 and 3 tons ha^{-1}) and integrated nutrient treatment (i.e. overoptimistic (3 ton ha^{-1} + NPS fertilizers 200 kg ha^{-1}) than chemical fertilizer treatment. Nasrin et al. (2019) revealed that the soil organic carbon content increases with the overoptimistic at 12 tons ha^{-1} in comparison to control treatment.

3.1.2 Available N, P, K and micronutrient content

The roles of nitrogen, phosphorus and potassium as the important macronutrients that are essential for regular growth and development of crop plants (Uchida 2000). The various treatments as followed in present experiment expressed no considerable differences in the soil available nitrogen and phosphorus content whereas, average data revealed the significant variations in the soil available potassium content among different treatments (Figure 1 and 2). The increased K content was observed with integrated nutrient management treatment (174.67 kg ha^{-1}) which lies at par to the neem leaves overoptimistic (174.28 kg ha^{-1}) and dhaincha leaves overoptimistic (173.39 kg ha^{-1}) treatments but showed significant increase of 2.36% and 2.43% in comparison to paddy straw overoptimistic and cow dung overoptimistic treatments respectively. Priyanka et al. (2019) investigated that the reason for increased soil available K content with integrated nutrient management may be because, FYM is noted

as best K source as well as retain the K^+ ions on exchangeable sites by decreasing its loss through leaching and organic matter and clay interaction responsible for K release.

Micronutrients are the elements required by the plants in very small amounts. Considerable differences were noted in the micronutrient content of the soil (Figure 1-2). The present study conducted has shown the increased available micronutrient content with different overoptimistic treatments in comparison to INM and control treatments. The higher soil available Fe content was recorded with paddy straw overoptimistic treatment and higher Zn, Cu and Mn content with dhaincha leaves overoptimistic treatment. This might be due to the higher micronutrient content of overoptimistic which are otherwise not supplied by the synthetic NPK fertilizers.

3.2 Maturity days

The differences noted in the maturity of maize crop among different treatments have shown very slight variations. The crop supplied with integrated nutrient management and RDF treatments was matured comparatively earlier such as 98 days after sowing in comparison to different overoptimistic treatments such as 102 days after sowing. This might be due to the readily and timely availability of nutrients due to increased mineralization rate in the integrated nutrient management and RDF treatments and hence dry matter accumulation rate is faster and vegetative growth period is reduced in comparison to the overoptimistic treatments. Vermicompost being slow-release fertilizer, supply nutrients slowly and steadily depending on its mineralization rate and hence extend the vegetative phase of the crop, therefore, delaying the maturity of crop.

3.3 Yield attributing characteristics of maize

3.3.1Plant height

Plant height is an index of growth and development that represents the infrastructure build-up over time, and also an indicator of growth promoting and suppressing ability of treatments. In the current study, plant height was significantly influenced with the overoptimistic and chemical fertilizer treatments (Table 2). During first and second year the maximum plant height was obtained in integrated nutrient management (INM) treatment (208.6 cm) which is in close count of RDF treatment (208.0 cm) (Table 2). INM treatment as followed by different overoptimistic treatments which further showed significant difference in comparison to the control treatment. The conclusion could be attributed to the fact that the regular and timely supply of nitrogen with integrated nutrient management and RDF treatments is responsible for comparatively increased plant development during initial growth stages because nitrogen improves the vegetative growth, which further responsible for higher production of photosynthetic materials and hence improve the plant height, while organic fertilizers improved plant growth during later growth stages. Prajapati et al. (2018) reported increased plant height with integrated nutrient treatment (100 per cent overoptimistic + 100 percent RDF) in comparison to control, RDF and overoptimistic treatments.

Table 1: Effects of inorganic fertilizer application on pH, EC & OC content of soil after harvesting of maize.

T	pH (1:2)			EC (dS m^{-1})			OC (%)		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1	7.20 ± 0.06	7.40 ± 0.12	7.30 ± 0.03	0.38 ± 0.01	0.43 ± 0.01	0.40 ± 0.00	0.38 ± 0.01	0.39 ± 0.01	0.38 ± 0.00
T_2	7.34 ± 0.05	7.47 ± 0.13	7.40 ± 0.04	0.39 ± 0.01	0.47 ± 0.01	0.43 ± 0.00	0.40 ± 0.01	0.41 ± 0.02	0.40 ± 0.01
T_3	7.21 ± 0.06	7.37 ± 0.15	7.29 ± 0.04	0.41 ± 0.01	0.48 ± 0.01	0.44 ± 0.00	0.41 ± 0.01	0.43 ± 0.01	0.42 ± 0.00
T_4	7.20 ± 0.06	7.32 ± 0.13	7.26 ± 0.04	0.42 ± 0.01	0.49 ± 0.01	0.45 ± 0.01	0.41 ± 0.01	0.42 ± 0.01	0.41 ± 0.00
T_5	7.15 ± 0.07	7.24 ± 0.12	7.19 ± 0.09	0.44 ± 0.01	0.53 ± 0.02	0.48 ± 0.01	0.42 ± 0.01	0.44 ± 0.02	0.43 ± 0.01
T_6	7.06 ± 0.01	7.18 ± 0.07	7.12 ± 0.04	0.45 ± 0.01	0.56 ± 0.01	0.50 ± 0.01	0.43 ± 0.01	0.45 ± 0.02	0.44 ± 0.01
T_7	7.16 ± 0.07	7.28 ± 0.14	7.22 ± 0.11	0.43 ± 0.01	0.51 ± 0.01	0.47 ± 0.01	0.40 ± 0.01	0.42 ± 0.01	0.41 ± 0.01
CD (p=0.05)	ns	ns	ns	0.03	0.04	0.02	ns	ns	0.03

Table 2: Effects of inorganic fertilizer application on maize crop yield attributing characteristics.

T	Plant height (cm)			Tassel size (cm)			Ear length (cm)			No. of leaves		
	2019-20	**2020-21**	**Mean**	**2019-20**	**2020-21**	**Mean**	**2019-20**	**2020-21**	**Mean**	**2019-20**	**2020-21**	**Mean**
T_1	162.8 ± 1.8	164.7 ± 1.1	163.8 ± 0.8	24.0 ± 0.2	24.3 ± 0.3	24.2 ± 0.2	21.5 ± 1.0	21.8 ± 0.9	21.6 ± 1.0	11.0 ± 0.3	11.2 ± 0.3	11.1 ± 0.3
T_2	208.0 ± 1.7	210.5 ± 1.0	209.3 ± 1.2	27.0 ± 1.4	27.4 ± 1.4	27.2 ± 1.4	26.6 ± 2.0	27.0 ± 2.1	26.8 ± 2.0	12.4 ± 0.3	12.6 ± 0.4	12.5 ± 0.3
T_3	208.6 ± 1.7	211.9 ± 1.2	210.2 ± 0.7	28.9 ± 0.6	29.1 ± 0.4	29.0 ± 0.5	28.8 ± 0.2	29.2 ± 0.3	29.0 ± 0.2	12.4 ± 0.3	12.7 ± 0.2	12.6 ± 0.3
T_4	175.7 ± 1.5	179.5 ± 1.3	177.6 ± 1.4	26.7 ± 1.4	27.1 ± 1.3	27.0 ± 1.4	25.5 ± 0.9	26.1 ± 0.8	25.8 ± 0.8	11.0 ± 0.1	11.3 ± 0.1	11.1 ± 0.1
T_5	195.7 ± 1.7	199.7 ± 1.2	197.7 ± 1.5	27.2 ± 1.0	27.4 ± 0.9	27.3 ± 0.9	26.0 ± 0.9	26.3 ± 0.9	26.1 ± 0.9	11.1 ± 0.3	11.3 ± 0.3	11.2 ± 0.3
T_6	183.9 ± 1.7	189.6 ± 1.1	186.7 ± 0.8	27.1 ± 1.6	27.3 ± 1.6	27.2 ± 1.6	25.9 ± 1.3	26.2 ± 1.4	26.0 ± 1.3	11.1 ± 0.4	11.4 ± 0.4	11.2 ± 0.4
T_7	174.3 ± 1.7	181.2 ± 1.2	177.8 ± 0.8	25.8 ± 1.6	26.0 ± 1.5	26.0 ± 1.5	25.6 ± 1.7	25.8 ± 1.7	25.7 ± 1.7	11.0 ± 0.2	11.3 ± 0.3	11.2 ± 0.2
CD (p=0.05)	7.4	3.4	3.9	ns	ns	2.2	ns	ns	2.6	0.9	0.9	0.6

T_1- Control, T_2- RDF (Recommended dose of fertilizers), T_3- RDF+FYM (Recommended dose of fertilizers + Farmyard manure), T_4- {Paddy Straw + Cow dung (1:1)} + 1kg earthworms, T_5- {Neem leaves + Cow dung (1:1)} + 1kg earthworms, T_6- {Dhaincha leaves + Cow dung (1:1)} + 1kg earthworms and T_7- {Cow Dung (100%)} + 1 kg earthworms.

Table 3: Effect of inorganic fertilizer application on yield attributing characteristics of maize cobs.

T	Cob length (cm)			Cob weight (g)			Grains per cob			Grain rows		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1	13.6 ± 0.4	14.9 ± 0.2	14.3 ± 0.3	104.2 ± 1.4	119.5 ± 1.9	111.8 ± 0.6	374.9 ± 1.8	385.5 ± 1.3	380.2 ± 1.6	13.4 ± 0.2	13.6 ± 0.2	13.4 ± 0.2
T_2	18.3 ± 0.7	20.6 ± 0.5	19.5 ± 0.6	171.8 ± 1.9	191.5 ± 2.4	181.7 ± 1.8	463.1 ± 1.6	453.1 ± 2.2	444.6 ± 1.2	13.8 ± 0.1	14.0 ± 0.1	13.8 ± 0.1
T_3	18.8 ± 0.1	21.5 ± 0.4	20.2 ± 0.2	175.0 ± 1.3	196.0 ± 2.2	185.5 ± 1.6	459.4 ± 1.6	480.4 ± 1.9	469.9 ± 0.2	14.0 ± 0.1	14.2 ± 0.1	14.0 ± 0.1
T_4	15.9 ± 0.2	18.6 ± 0.3	17.2 ± 0.2	132.6 ± 1.8	162.6 ± 1.6	147.6 ± 0.9	411.2 ± 1.1	425.9 ± 2.1	418.5 ± 1.6	13.4 ± 0.1	13.6 ± 0.1	13.6 ± 0.1
T_5	16.5 ± 1.3	19.4 ± 0.8	18.0 ± 1.1	167.6 ± 2.3	189.0 ± 2.1	178.3 ± 1.1	432.6 ± 1.8	455.7 ± 2.0	444.2 ± 0.9	13.8 ± 0.2	14.0 ± 0.2	14.0 ± 0.2
T_6	15.8 ± 0.2	19.1 ± 0.5	17.5 ± 0.2	154.2 ± 2.3	183.2 ± 1.9	168.7 ± 1.5	428.6 ± 1.8	449.7 ± 1.7	439.2 ± 0.7	13.8 ± 0.1	13.8 ± 0.1	13.8 ± 0.1
T_7	15.8 ± 0.5	18.9 ± 0.6	17.4 ± 0.6	132.9 ± 1.6	168.6 ± 2.5	150.8 ± 1.3	422.3 ± 2.0	437.4 ± 1.2	429.8 ± 1.1	13.6 ±0.2	13.8 ± 0.1	13.8 ± 0.1
CD (p=0.05)	1.9	1.6	1.2	5.9	6.8	4.3	5.6	5.5	3.7	ns	ns	ns

Note: For treatments detail see table 1.

Table 4: Effect of inorganic fertilizer application on yield attributing characteristics of maize cobs.

Treatment	Grains/row			Grain size						1000 grain weight (g)		
				Grain length(mm)			Grain thickness(mm)					
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1	22.7 ± 0.4	28.1 ± 0.5	27.9 ± 0.5	8.9 ± 0.4	8.9 ± 0.5	8.9 ± 0.4	4.8 ± 0.1	5.0 ± 0.3	4.9 ± 0.1	200.6 ± 2.4	204.2 ± 2.6	202.4 ± 2.5
T_2	32.5 ± 0.2	32.8 ± 0.1	32.7 ± 0.1	9.2 ± 0.7	9.3 ± 0.7	9.3 ± 0.7	4.9 ± 0.1	5.0 ± 0.2	5.0 ± 0.1	301.8 ± 3.9	305.1 ± 3.6	303.4 ± 3.8
T_3	32.7 ± 1.0	33.0 ± 0.9	32.8 ± 0.9	10.1 ± 0.1	10.1 ± 0.1	10.1 ± 0.1	5.1 ± 0.3	5.9 ± 0.9	5.5 ± 0.4	304.2 ± 2.6	308.5 ± 2.9	306.3 ± 2.7
T_4	27.9 ± 0.8	28.2 ± 0.7	28.1 ± 0.7	9.0 ± 0.3	9.0 ± 0.3	9.0 ± 0.3	4.9 ± 0.1	5.0 ± 0.2	4.9 ± 0.2	239.0 ± 1.2	246.3 ± 1.4	242.6 ± 1.3
T_5	30.0 ± 0.9	30.7 ± 0.8	30.3 ± 0.8	9.2 ± 0.5	9.3 ± 0.5	9.3 ± 0.5	4.9 ± 0.3	4.8 ± 0.1	4.9 ± 0.2	255.1 ± 2.6	264.4 ± 2.9	259.8 ± 2.7
T_6	28.0 ± 1.9	28.5 ± 1.8	28.2 ± 1.9	9.1 ±0.4	9.1 ± 0.3	9.1 ± 0.3	4.9 ± 0.1	4.9 ± 0.1	4.9 ± 0.1	249.9 ± 2.0	257.5 ± 1.7	253.7 ± 1.8
T_7	28.0 ± 1.3	28.4 ± 1.0	28.2 ± 1.1	9.0 ± 0.1	9.1 ± 0.4	9.0 ± 0.2	4.9± 0.2	4.9 ± 0.1	4.9 ± 0.2	244.2 ± 1.7	250.1 ± 2.3	247.1 ± 2.0
CD (p=0.05)	3.3	2.9	2.1	ns	ns	ns	ns	ns	ns	8.2	8.4	5.6

T_1- Control, T_2- RDF (Recommended dose of fertilizers), T_3- RDF+FYM (Recommended dose of fertilizers + Farmyard manure), T_4- {Paddy Straw + Cow dung (1:1)} + 1kg earthworms, T_5- {Neem leaves + Cow dung (1:1)} + 1kg earthworms, T_6- {Dhaincha leaves + Cow dung (1:1)} + 1 kg earthworms and T_7- {Cow Dung (100%)} + 1 kg earthworms.

Preetham et al. (2020) reported the maximum plant height within integrated nutrient management treatment plots (25 per cent N through overoptimistic + 75 per cent RDF + *Azospirillum* and *Bacillus megaterium* at 5 kg ha^{-1} each) in comparison to control and RDF treatments.

3.32 Leaf number per plant, tassel size and ear length

The effect of inorganic fertilizers and different overoptimistic treatments on Number of leaves was recorded significant. The average two-year study revealed a greater number of leaves with INM treatment which lies at par to the RDF treatment (Table 2). No significant differences were observed among different overoptimistic and control treatments. The comparatively increased output of INM and RDF treatments was might be because of the increased and timely nitrogenous supply that leads to increased biochemical activity of photosynthesis which results in increased leaf number and hence dry matter accumulation. Tassel is the male flower present at the top of the corn plant. It is responsible for producing pollens and pollinates silk (female flowers) through anemophily. The average of tassel size, resulting from two-year data, lies in the range of 24.2 and 29.0 cm (Table 4). The recorded maximum tassel size was in INM treatment and minimum was in control treatment. The effect of different treatments on ear length was non-significant (Table 4).

3.4 Yield and yield components of maize

3.4.1 Cob length and cob weight

The cob length is associated to grains number in each row, which determines total Number of grains per cob and hence grain yield. The cob length varied from 13.6 to 18.8 cm during first year and 14.9 to 21.5 cm during second year whereas the cob weight lies in the range of 104.2 g to 175.0 g during the first year and increased from 119.5 to 196.0 g during second year among different treatments (Table 3). During both the years, the highest cob length and cob weight was noted in integrated nutrient management treatment, may be due to the improved and more regular supply of nitrogen and phosphorus for plant use, as nitrogen is the most important element to improve the cob size and grain numbers. Whereas, following integrated nutrient management, different overoptimistic treatments showed significant differences than control. Vermicompost, being slow-release organic fertilizer improves cob weight in comparison to control because of the more availability of nutrients due to slow and steady decomposition of microbial rich overoptimistic. Further, differences in the nutrient content of the different prepared overoptimistic (depending on the raw material used) influence the crop growth factors accordingly. The cob weight lies in the range of 104.2 g to 175.0 g during the first year and increased from 119.5 to 196.0 g during second year. Similar findings were recorded by Biswasi et al. (2020) and Preetham et al. (2020). However, during the second year, the differences in cob length between integrated nutrient management and different overoptimistic treatments were comparatively lower than that recorded in the first year.

3.4.2 Grains per cob, grain rows, grains per row and grain size

The grains number per cob has a direct impact on maize grain production. The effect of integrated nutrient management treatment was noted significant for grains per cob and grains per row in comparison to the other treatments (Table 3 & 4). The joint action of inorganic and organic fertilizer considered responsible for increasing the vegetative growth, production of photosynthetic products, flowering duration and fertility, and hence the grain number per cob. Further the effect of different overoptimistic treatments on yield attributing characteristics of maize was significant than control. Furthermore, no significant difference was observed in grain rows and grain size among different treatments (Table 3&4).

3.4.3 Thousand grains weight

Thousand grains weight (g) of maize hybrid as affected by the different treatments lies in the range of 200.6 and 304.2 g during the first year, whereas it was comparatively increased during the second year and lies in the range of 204.2 and 308.5 g (Table 4). Thousand-grains weight observed in RDF and integrated nutrient treatment was maximum and lies close to each other during both the years. Whereas both the treatments showed a significant increase in thousand grains weight compared to overoptimistic and control treatments.

3.4.5 Grain and straw yield

Gardner et al. (1985) stated that the maize grain yield is the outcome of three yield parameters product including ear number per unit area, grain number per ear and unit grain weight. Any decrease noticed in these three components (even the other components being constant), will result in the decrease of final grain yield, and therefore, the management factor that is responsible to increase any of the one parameter will ultimately contribute to increase the resultant grain yield. It was reasonably determined from the present experiment that the maximum average grain and stover yield was recorded with integrated nutrient management treatment followed by RDF, neem leaves overoptimistic, dhaincha leaves overoptimistic, cow dung overoptimistic and paddy straw overoptimistic treatments (Table 5). Whereas, the control treatment showed minimum yield. The surge in the grain yield in the second year is attributable to the average increase of maize growth and yield parameters due to soil nutrient build-up which ultimately leads to improved crop yield.

3.5 Quantitative attributes

3.5.1 Chemical analysis of maize grain and stover

The chemical analysis of maize grains revealed no significant difference in the maize grains N, K, Fe, Zn, Cu, Mn, and protein content. In contrast, a slight increase was observed in the P content of maize grains among different treatments (Table 6&7). The chemical analysis of maize stover reported with no considerable differences in N, Cu and Mn content of maize stover among different treatments, whereas considerable variations were observed in P, K, Fe and Zn content of maize stover. Following integrated nutrient management, RDF treatment showed improved nutrient content in maize stover may be because of better root and shoot

Table 5. Effect of inorganic fertilizer application on maize grain and stover yield.

Treatments	Grain yield (q ha^{-1})			Stover yield (q ha^{-1})		
	2019-20	**2020-21**	**Mean**	**2019-20**	**2020-21**	**Mean**
T_1	31.1 ± 1.7	32.4 ± 1.4	31.8 ± 0.8	43.2 ± 1.9	45.9 ± 1.4	44.6 ± 1.7
T_2	52.3 ± 1.6	54.8 ± 1.6	53.5 ± 1.6	84.4 ± 1.5	87.2± 1.6	85.8 ± 1.6
T_3	56.6 ± 1.8	57.2 ± 1.2	56.9 ± 1.3	93.3 ± 1.4	97.4 ± 1.4	95.4 ± 1.4
T_4	41.7 ± 1.4	45.7 ± 1.6	43.7 ± 1.2	74.1 ± 1.9	81.6 ± 1.8	77.8 ± 1.8
T_5	43.8 ± 1.7	52.9 ± 1.6	48.4 ± 1.4	77.8 ± 1.7	87.2 ± 1.4	82.5 ± 1.5
T_6	42.7 ± 1.6	51.0 ± 1.0	46.9 ± 1.2	77.6 ± 1.9	87.0 ± 1.9	82.3 ± 1.9
T_7	42.4 ± 1.7	46.4 ± 1.6	44.3 ± 1.3	76.2 ± 1.7	82.8 ± 1.6	79.5 ± 1.6
CD (p=0.05)	5.3	4.7	3.3	5.0	3.9	3.0

Note: For treatments detail see table 1.

Table 6. Effect of inorganic fertilizer application on nutrient content of Maize grain

T	N (%)	PC (%)	P (%)	K (%)	Fe (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Mn (mg kg^{-1})
T_1	1.49 ± 0.02	9.31 ± 0.11	0.30 ± 0.02	0.58 ± 0.01	163.40 ± 1.27	20.56 ± 1.76	10.83 ± 0.59	21.64 ± 1.24
T_2	1.53 ± 0.02	9.56 ± 0.14	0.32 ± 0.02	0.67 ± 0.04	169.16 ± 1.47	23.15 ± 1.16	13.20 ± 1.18	24.76 ± 1.27
T_3	1.54 ± 0.02	9.63 ± 0.13	0.34 ± 0.02	0.69 ± 0.11	169.46 ± 1.43	23.92 ± 1.18	13.80 ± 1.57	26.00 ± 1.16
T_4	1.50 ± 0.01	9.38 ± 0.07	0.33 ± 0.02	0.74 ± 0.01	164.36 ± 1.64	22.90 ± 1.18	13.30 ± 0.55	22.48 ± 1.12
T_5	1.52 ± 0.01	9.5 ± 0.08	0.36 ± 0.02	0.73 ± 0.06	167.46 ± 1.10	23.69 ± 1.22	14.12 ± 0.61	24.32 ± 1.11
T_6	1.55 ± 0.01	9.69 ± 0.07	0.42 ± 0.01	0.76 ± 0.05	169.47 ± 1.74	23.95 ± 1.17	14.20 ± 0.52	24.86 ± 1.11
T_7	1.51 ± 0.01	9.45 ± 0.07	0.39 ± 0.02	0.74 ± 0.01	165.33 ± 1.14	23.55 ± 1.19	13.54 ± 0.49	23.08 ± 1.15
CD (p=0.05)	ns	ns	0.06	ns	ns	ns	ns	ns

Note: For treatments detail see table 1.

Table 7: Effect of inorganic fertilizer application on nutrient content of Maize stover.

T	N	P	K	Fe	Zn	Cu	Mn
	%			(mg kg^{-1})			
T_1	0.51 ± 0.01	0.15 ± 0.01	1.21 ± 0.01	194.31 ± 0.43	10.86 ± 0.96	4.05 ± 0.01	8.43 ± 1.24
T_2	0.54 ± 0.01	0.23 ± 0.01	1.51 ± 0.01	215.64 ± 0.86	14.74 ± 0.22	4.93 ± 0.05	11.05 ± 1.28
T_3	0.55 ± 0.01	0.25 ± 0.01	1.57 ± 0.01	220.12 ± 0.23	16.54 ± 0.87	5.26 ± 0.58	11.39 ± 1.04
T_4	0.52 ± 0.01	0.17 ± 0.01	1.25 ± 0.01	214.84 ± 0.57	12.87 ± 0.51	4.42 ± 0.01	9.14 ± 1.11
T_5	0.53 ± 0.01	0.19 ± 0.01	1.38 ± 0.02	217.62 ± 0.38	13.88 ± 0.25	4.78 ± 0.21	9.64 ± 1.48
T_6	0.53 ± 0.01	0.21± 0.01	1.42 ± 0.02	219.33 ± 0.24	14.08 ± 0.13	4.85 ± 0.49	10.13 ± 1.14
T_7	0.52 ± 0.01	0.18 ± 0.01	1.29± 0.01	215.53 ± 0.21	12.92 ± 0.39	4.51 ± 0.05	9.65 ± 0.99
CD (p=0.05)	ns	0.04	0.05	1.26	1.50	ns	ns

Note: For treatments detail see table 1.

Table 8. Effect of inorganic fertilizer application on nutrient uptake of maize grain.

T	Nutrient uptake (kg ha^{-1})						
	N	P	K	Fe	Zn	Cu	Mn
T	46.34 ± 1.73	9.33 ± 1.60	18.04 ± 0.55	0.51 ± 0.01	0.06 ± 0.02	0.03 ± 0.01	0.07 ± 0.02
T_2	80.02 ± 1.73	16.74 ± 1.05	35.04 ± 1.10	0.88 ± 0.02	0.12 ± 0.01	0.07 ± 0.02	0.13 ± 0.01
T_3	87.16 ± 1.12	19.24 ± 2.26	39.05 ± 1.10	0.96 ± 0.01	0.14 ± 0.02	0.08 ± 0.01	0.15 ± 0.02
T	62.55 ± 1.07	13.76 ± 1.76	30.86 ± 0.69	0.69 ± 0.02	0.10 ± 0.01	0.06 ± 0.02	0.09 ± 0.01
T_5	66.58 ± 1.22	15.77 ± 1.73	31.97 ± 0.65	0.73 ± 0.01	0.01 ± 0.01	0.06 ± 0.01	0.11 ± 0.02
T_6	66.18 ± 1.12	17.93 ± 1.78	32.45 ± 1.62	0.72 ± 0.02	0.10 ± 0.01	0.06 ± 0.02	0.11 ± 0.01
T_7	64.02 ± 0.83	16.54 ± 0.90	31.38 ± 1.62	0.70 ± 0.01	0.10 ± 0.02	0.06 ± 0.01	0.10 ± 0.02
CD (p=0.05)	**4.19**	**5.41**	**4.01**	**0.05**	**NS**	**NS**	**NS**

Note: For treatments detail see table 1.

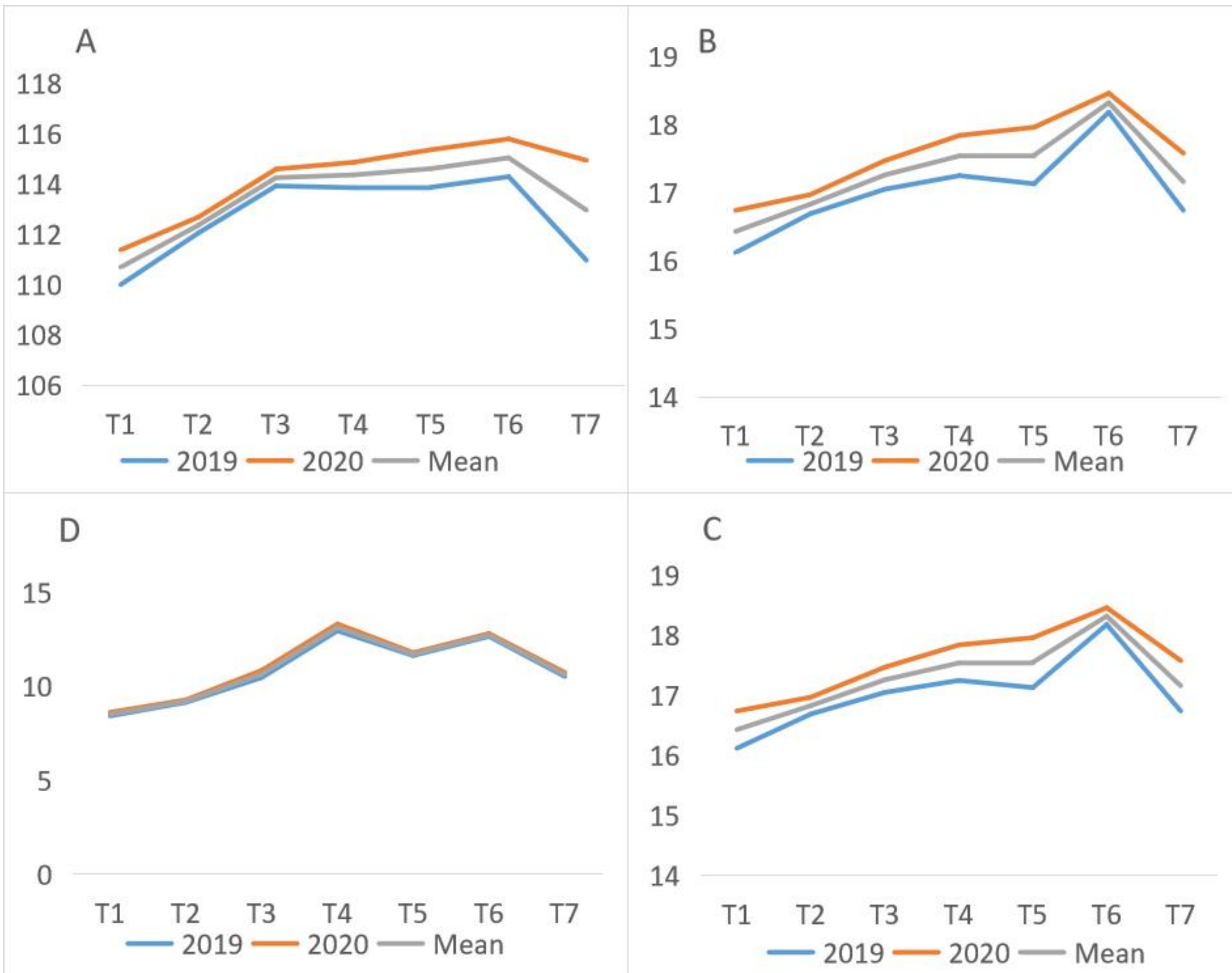

Figure 1. Effect of inorganic fertilizer application on (A) Soil available N, (B) Soil available P (C) Soil available K (D) Soil available Fe .

Table 9. Effect of inorganic fertilizer application on nutrient uptake of maize stover.

T	Nutrient uptake (kg ha^{-1})						
	N	P	K	Fe	Zn	Cu	Mn
T_1	46.67 ± 1.86	6.48 ± 1.59	52.28 ± 1.85	0.84 ± 0.01	0.05 ± 0.01	0.02 ± 0.01	0.04 ± 0.01
T_2	97.08 ± 1.35	19.42 ± 1.97	127.47 ± 1.20	1.82 ± 0.01	0.12 ± 0.01	0.04 ± 0.01	0.09 ± 0.01
T_3	109.13 ± 1.21	23.32 ± 1.57	146.43 ± 1.51	2.05 ± 0.01	0.15 ± 0.01	0.05 ± 0.01	0.11 ± 0.01
T_4	83.72 ± 1.39	12.60 ± 1.97	92.61 ± 2.11	1.59 ± 0.01	0.10 ± 0.01	0.03 ± 0.01	0.07 ± 0.01
T_5	96.50 ± 1.28	14.79 ± 1.76	107.38 ± 2.40	1.69 ± 0.01	0.11 ± 0.01	0.04 ±0.01	0.07 ± 0.01
T_6	99.30 ± 1.45	16.30 ± 1.80	110.16 ± 1.68	1.70 ± 0.01	0.11 ± 0.01	0.04 ± 0.01	0.08 ± 0.01
T_7	89.14 ± 1.48	13.71 ± 1.25	98.29 ± 1.56	1.64 ± 0.01	0.10 ± 0.01	0.03 ± 0.01	0.07 ± 0.01
CD (p=0.05)	4.79	5.61	5.85	0.05	0.04	NS	NS

Note: For treatments detail see table 1.

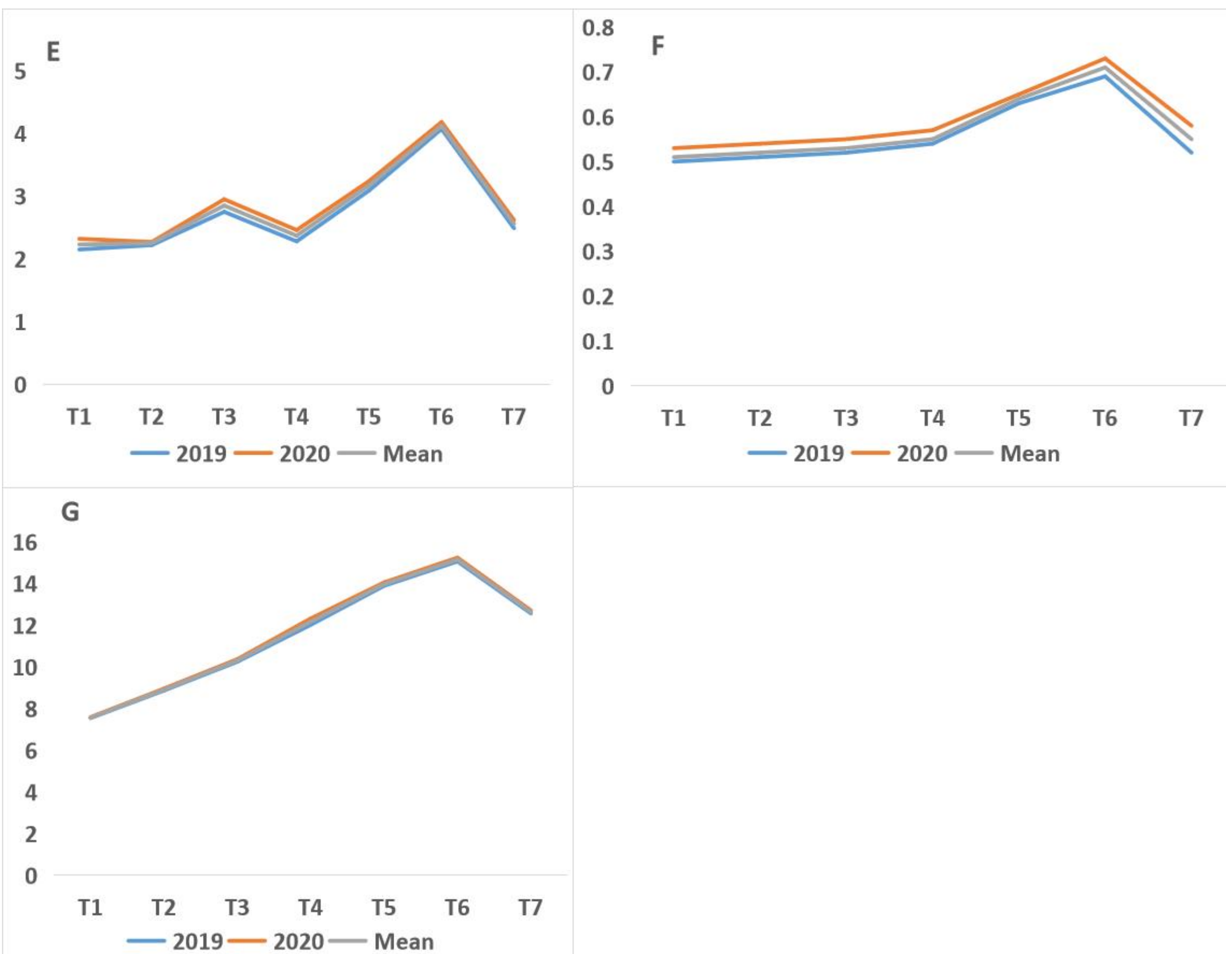

Figure 2. Effect of inorganic fertilizer application on (E) Soil available Zn (F) Soil available Cu (G) Soil Available Mn.

growth that results in increased nutrient uptake from the soil. However, increased nutrient content with dhaincha leaves overoptimistic may be due to the comparatively increased nutrient content in matured dhaincha leaves overoptimistic in comparison to other vermicomposts.

3.5.2 Nutrient uptake of maize grain and stover

The nutrient uptake of maize grain was computed by multiplying the nutrient content of grains with yield recorded in the particular treatment. Higher nutrient uptake was noted with INM treatment followed by RDF, different overoptimistic and control treatments (Table 8&9). The higher uptake of nutrients is attributed to higher yields along with higher nutrient content absorbed in these treatments.

4. Conclusion

The application of chemical fertilizers along with organic manure is growing popular among farmers due to growing awareness and enhanced productivity while maintaining soil fertility. In the present experiment, the maximum yield attributes were recorded with integrated nutrient management followed by recommended dose of fertilizer treatment, which lied at par to the neem leaves overoptimistic treatment and showed significant increase in comparison to other overoptimistic treatments. However, all the treatments showed better results in comparison to control. The combination of both was reported quite suitable because the joint action of FYM and chemical fertilizers leads to stabilized crop production and maintain greater productivity. Furthermore, when the organic and inorganic fertilizers are applied in combination, improves the N. P and K content as the process like decomposition and mineralization increases the nutrient availability in the soil. Further, nutrient losses also take with the chemical fertilizers' application. The organic fertilizers such as FYM and overoptimistic are slow releasing fertilizers. These fertilizers upon decomposition and mineralization improves the nutrient and organic carbon status of the soil and hence improves the crop growth and yield. The long-term experiments should be conducted to evaluate the improvement in crop growth and yield with the continuous application of organic fertilizers to the soil for further several years.

Acknowledgement:

Authors are grateful to Dr Sohan Singh Walia (Director-cum-Principal Agronomist) for providing the facilities to conduct the research. We thank all the lab staff for consistent support and help during the research work.

Author’s contribution:

Conceptualization and designing: Neeraj Rani and Karanbir Kaur Bal Manuscript Preparation: Karanbir Kaur Bal

Declaration of competing interest:

The authors bear no competing interest.

Funding acknowledgement statement: No funding sources.

REFERENCES

Ali, I., He, L., Ullah, S., Quan, Z., Wei, S., Iqbal, A., Munsif, F., Shah, T., Xuan, Y., Luo, Y. and Tianyuan, L. Biochar addition coupled with nitrogen fertilization impacts on soil quality, crop productivity, and nitrogen

uptake under double-cropping system. Food and Energy Security, (2020). 9 (3) 208.

Ali, I., Khan, A. A., Munsif, F., He, L., Khan, A., Ullah, S., Saeed, W., Iqbal, A., Adnan, M. and Ligeng, J. Optimizing rates and application time of potassium fertilizer for improving growth, grain nutrients content and yield of wheat crop. Open Agriculture, (2019). 4 (1), 500.

Ali, I., Yuan, P., Ullah, S., Iqbal, A., Zhao, Q., Liang, H., Khan, A., Zhang, H., Wu, X., Wei, S. and Gu, M. Biochar Amendment and Nitrogen Fertilizer Contribute to the Changes in Soil Properties and Microbial Communities in a Paddy Field. Frontiers in Microbiology, (2022). 13, 834751.

Amin, A., Nasim, W., Mubeen, M., Mubeen, M., Nadeem, M., Ali, L., Mohkum Hammad, H., Refat Sultana, S., Jabran, K., …. Fathi, A. Optimizing the phosphorus use in cotton by using CSM-CROPGRO-cotton model for semi-arid climate of Vehari-Punjab, Pakistan. Environmental Science and Pollution Research, (2017). 24, 5811.

Biswasi S. K., Barik A. K., Bastia D. K., Dalei B., Nayak L., Ray M. Effect of integrated nutrient management on growth, productivity and economics of hybrid maize in Odisha state. International Journal Bio-resource Stress Management, (2020). 11 (5), 465.

Oluwatoyin Bolanle, O., Olaide, I., Fatima, R. and Josephine Olabisi, A. Sustainable agriculture through improved on farm processing techniques and value-added organic food products. New and Future Developments in Microbial Biotechnology and Bioengineering, (2022). 477.

Brandy, N. C. and Weil, R. R. The nature and properties of Soils. Prentice Hill. Inc, New Jersy, (2002). 890.

Bremner, J. M. and Hauck, R. D. Advances in methodology for research on nitrogen transformations in soils. Nitrogen in agricultural soils, (1982). 22, 467.

Cheema, H. S. and Singh, B. Software Statistical Package CPCS-1. Department of Statistics, Punjab Agricultural University, Ludhiana, (1991). (Available at Cheema H. S., Singh B. (1991): Software Statistical... - Google Scholar).

Chimdessa, D. and Sori, G. Integrated Effects of Vermi-compost and NPS Fertilizer Rates on Soil Chemical Properties and Maize Production in Bedele District, Western Oromia. Plant, (2020). 8 (4), 115.

Dai, J. and Dong, H. Intensive cotton farming technologies in China: Achievements, challenges and countermeasures. Field Crops Research, (2014). 155, 99.

Devkota, M., Singh, Y., Atnafe Yigezu Y., Bashour I., Mussadek R., Mrabet R. Conservation agriculture in the drylands of the Middle East and North Africa (MENA) region: Past trend, current opportunities, challenges and future outlook. Advances in Agronomy, (2022). 172, 253.

Guillermo Divito, A., Victor Sadras O. How do phosphorus, potassium and sulphur affect plant growth and biological nitrogen fixation in crop and pasture legumes? A meta-analysis. Field Crops Research, (2014). 156, 161.

Foley Jonathan, A., Ramankutty N., Brauman Kate, A., Cassidy Emily, S., Gerber James, S., Johnston M., Mueller Nathaniel, D., Connell C., Ray Deepak, K., Paul West, C., Balzer C., Bennett Elena, M., Carpenter Stephen, R., Hill, J., Monfreda, C., Polasky, S., Rockstro, J., Sheehan, J., Siebert, S., Tilman, D. and David Zaks, P. M. Solutions for a cultivated planet. Nature, (2011). 478, 337.

Gardner Franklin, P., Pearce Brent, R. and Mitchell Roger, L. Physiology of crop plants. Scientific publishers, Jodhpur, India, (1985). 296.

Godfray Charles, H. J., Beddington John, R., Crute Ian, R., Haddad, L., Lawrence, D., Muir James, F., Pretty, J., Robinson, S., Thomas Sandy, M. and Toulmin, C. Food security: the challenge of feeding 9 billion people. science, (2010). 327(5967), 812.

Gomez Kwanchai, A. and Gomez Arturo, A. Statistical Procedures for Agriculture Research. John Wiley and Sons. New York, (1984).

Iqbal, A., He, L., Ali, I., Ullah, S., Khan, A., Khan, A., Akhtar, K., Wei, S., Zhao, Q., Zhang, J. and Jiang, L. Manure combined with chemical fertilizer increases rice productivity by improving soil health, post-anthesis biomass yield, and nitrogen metabolism. Plos One. (2020). 15(10), e0238934.

Jackson, M.L. Soil Chemical Analysis. Prentice-Hall of India Pvt. Ltd., New Delhi, (1967). 498.

Jayanthi, C., Malarvizhi, P., Khan Fazullah, A. K. and Chinnusamy, C. Integrated nutrient management in forage oat (Avena sativa). Indian Journal of Agronomy, (2002). 47, 130.

Khalid B. B. and Islam Z. T. Mineral Feeding of organic plants (authore: tourist KharShotor). Shiraz University publication, (2001). 945. (Accessed 14.7.2022)

Lindsey, W. L. and Norvell, W. A. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Science Society of America Journal, (1978). 42, 421.

Majnoon, H. N: Cereals Agronomy (Wheat, Barley, Rice, Zea Mays). Naghshmehr publication, (2006). 116.

Nanjappa, H. V., Ramachandrappa, B. K. and Mallikarjuna, B. O. Effect of integrated nutrient management on yield and nutrient balance in maize (Zea mays). Indian Journal of Agronomy, (2001). 46, 698.

Nasrin, A., Khanom, S. and Hossain Akhtar, S. Effects of overoptimistic and compost on soil properties and growth and yield of Kalmi (Ipomoea aquatica Forsk.) in mixed soil. Journal of Biological Sciences, (2019), 28, 121.

Olsen, B. C., Cole, C. V., Watenabe, F. S. and Dean L. A. Estimation of available phosphorus by extraction with sodium carbonate, USDA Circ., (1954). 939.

Prajapati Kumar, V., Swaroop, N., Masih, A. and Lakra, R. Effect of different dose of NPK and overoptimistic on growth and yield attributes of maize [Zea Mays (L.)] Cv. MM2255. Journal of Pharmacognosy and Phytochemistry, (2018). 7, 2830.

Preetham, R., Kumar Avil, K., Srinivas, A., Rao Manohar, M., Ramprakash, T. Influence of INM Practices on Growth, Yield and Proximate Characters of Baby Corn in Baby Corn (Zea mays L.)–Hyacinth Bean (Lablab purpureus var. typicus) Cropping System. International Journal of Bio-resource Stress Management, (2020). 11, 327.

Priyanka, C., Sharma, S. K., Singh, A. and Sharma, J. K. Effect of INM onnutrients uptake and yield of maize-wheat cropping sequence and changes in nutrient availability in Typic Haplustepts. Bioscan, (2019). 14, 145.

Raza Turab, S., Zhu, Y., Wu, J., Rene Eldon, R., Ali, Z., Feyissa, A., Khan, S., Anjum, R., Bazai Ahmed, N. and Chen, Z. Different ratios of Canna indica and maize–overoptimistic as biofertilizers to improve soil fertility and plant growth: A case study from

southwest China. Environmental Research, (2022). 215, 114374.

Sadiq, G., Khan Ali, A., Inamullah, Rab, A., Fayyaz, H., Naz, G., Nawaz, H., Ali, I., Raza, H., Amin, J., Ali, S. and Khan Ali, H. Impact of phosphorus and potassium levels on yield and yield components of maize. Pure and Applied Biology, (2017). 6(3), 1071.

Subbiah, B. V. and Asija, G. L. A rapid procedures for the estimation of available nitrogen in soils. Current Science, (1965). 25, 259.

Uchida R. Essential nutrients for plant growth: nutrient functions and deficiency symptoms. In: Silva J. A., Uchida R. S. (ed) Plant nutrient management in Hawaii's soils. University of Hawaii, Manoa, (2000). 31.

Walkley, A. and Black Armstrong, I. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil science, (1934). 37, 29.

Wu, K., Ali, I., Xie, H., Ullah, S., Iqbal, A., Wei, S., He, L., Huang, Q., Wu, X., Cheng, F. and Jiang, L. Impact of fertilization with reducing in nitrogen and phosphorous application on growth, yield and biomass accumulation of rice (Oryza sativa L.) under a dual cropping system. Peer J, (2021). 9, 11668.

How to cite this article:

Kaur, K., Rani, N., Evaluation of integrated nutrient management on soil health, maize productivity and grain quality. Journal of Soil, Plant and Environment (2022); 1(2)-pp; 44-60.
https://doi.org/10.56946/jspae.v1i2.71